

Tech Notes

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Telemetry Modernization with Open Architecture Software-Defined Radio Technology

Lincoln Laboratory is conducting a software-defined radio technology development program to improve the way telemetered information is collected and processed.

Telemetry—the automated measurement and transmission of data from remote sources to receiving stations—plays a vital role in collecting critical information from flight vehicles and space assets. A telemetry system installed on a flight vehicle, for example, could transmit the vehicle's air speed and Global Positioning System location to a flight termination system. Other data, such as the voltages, temperatures, and barometric or fuel pressures of onboard systems, may be of prime interest to flight-test engineers. Data are measured via onboard sensors, modulated onto a radio-frequency (RF) carrier, and transmitted, or telemetered, to a ground station. At the ground station, the telemetered information is received by a tracking antenna, demodulated, and reassembled into engineering data to provide real-time situational awareness of the flight vehicle and to be used in post-flight data analysis (e.g., of flight vehicle performance).

Limitations of Traditional Ground-Based Telemetry Systems

Ground-based telemetry systems have traditionally been implemented with special-purpose hardware components

(e.g., analog receivers, mixers, detectors, filters, amplifiers, demodulators), which are difficult and expensive to replace or upgrade. This specialized hardware cannot accommodate new requirements or capabilities, limiting the systems' frequency agility, channel bandwidth capacity, and demodulation types. Each function in the telemetry signal chain is generally realized in a separate piece of equipment, so these systems have a large physical footprint. Operations are error prone because of the need for manual system adjustments and configurations, are challenging to remotely control, and often require multiple human operators when more than one antenna is in use, as is typically the case. Furthermore, implementation of the signal processing within each hardware component is vendor proprietary; thus, the processing methods cannot be easily inspected, modified, or improved upon.

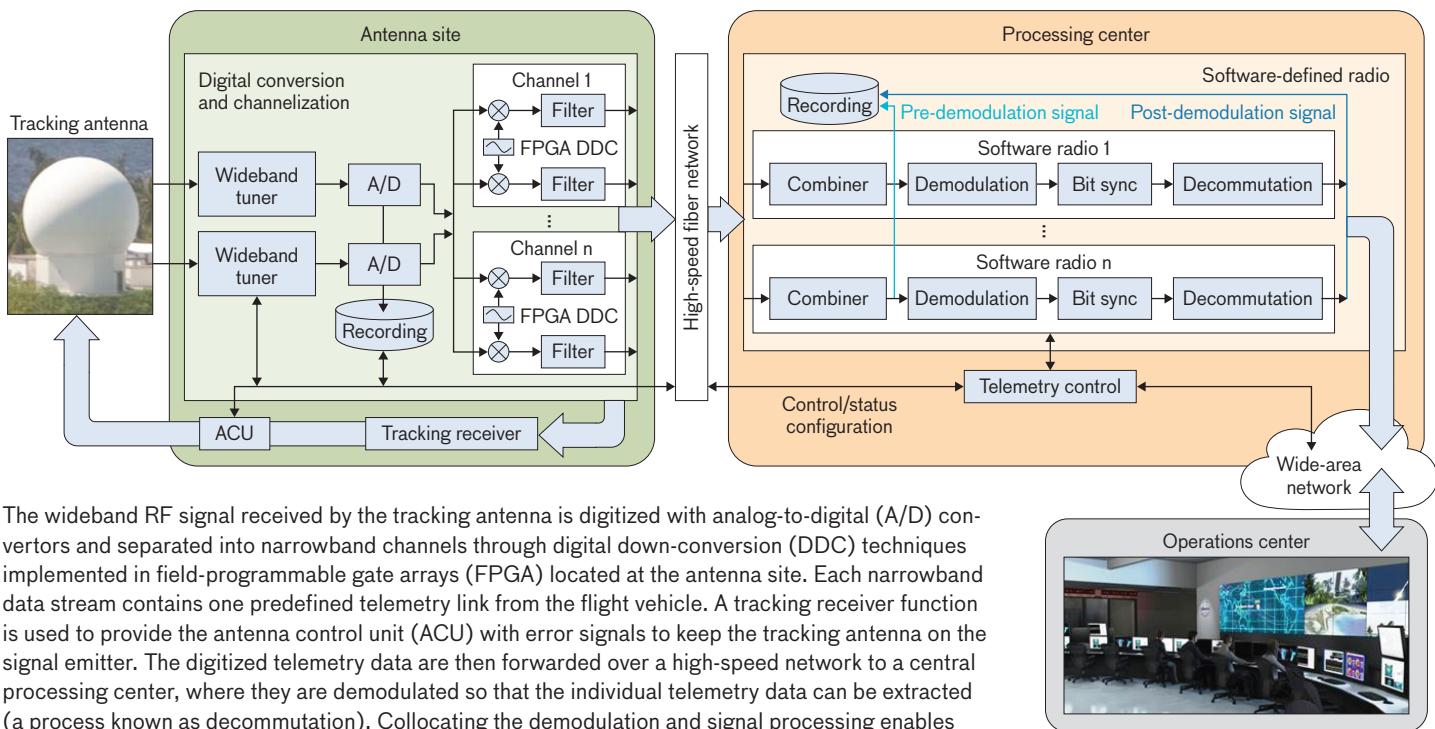
Telemetry Modernization Program

As part of its effort to upgrade the sensor suite at the U.S. Army Reagan Test Site (RTS) on the Kwajalein Atoll, Marshall Islands, Lincoln Laboratory is modernizing the test range's telemetry systems with a software-defined, radio-based open architecture. This architecture uses software modules running on general-purpose computers; these modules, which perform signal and data processing, will soon replace the narrowly capable (in frequency agility, bandwidth capacity, and sampling rate) hardware-based receivers that are currently in use at RTS. As the market demand for use of the existing

telemetry spectrum (e.g., expanding cellular communication frequencies) forces telemetry users to switch to a nontraditional set of frequencies, the software controlling the RTS telemetry systems' receiving and processing equipment can be modified to support operation within the new frequency range, eliminating the need to replace expensive hardware. New algorithms can be easily introduced into the processing chain as advanced modulations standards and other capabilities are employed to make efficient use of the limited frequency bands. Software can also be modified to support increased bandwidth or changes to signal-modulation and data-compression techniques.

Lincoln Laboratory is modernizing the telemetry systems at the U.S. Army Reagan Test Site on the Kwajalein Atoll, Marshall Islands, with open architecture software-defined radio technology.

Lincoln Laboratory is currently in the development stage of the program. Using the new signal processing software modules, the Laboratory demonstrated an approach for digitally combining the signals from multiple antennas to mitigate signal fading. The combined signal is computed as a time-varying weighted sum of the digital samples from each antenna and



The wideband RF signal received by the tracking antenna is digitized with analog-to-digital (A/D) convertors and separated into narrowband channels through digital down-conversion (DDC) techniques implemented in field-programmable gate arrays (FPGA) located at the antenna site. Each narrowband data stream contains one predefined telemetry link from the flight vehicle. A tracking receiver function is used to provide the antenna control unit (ACU) with error signals to keep the tracking antenna on the signal emitter. The digitized telemetry data are then forwarded over a high-speed network to a central processing center, where they are demodulated so that the individual telemetry data can be extracted (a process known as decommutation). Collocating the demodulation and signal processing enables the data from multiple tracking antenna sites on the network to be combined and processed. The entire telemetry system can be remotely configured and controlled from an operations center over a secure wide-area network.

is thus highly likely to improve upon the performance of any individual antenna. Traditionally, the best signal source has been selected on the basis of a variety of signal strength and signal quality metrics from individual antennas. While this approach can be effective, the selection criteria are not completely robust, and performance is limited to that of the signal from the single antenna with the highest signal-to-noise ratio.

Some of the other software modules are running concurrently with the legacy hardware-based systems, and the collected telemetry data are being compared to validate the new processing chain. Following validation, each of the 10 individual telemetry systems at RTS will be replaced with a fully integrated software radio-based telemetry system that can be configured and controlled remotely from the RTS Operations Center in Huntsville, Alabama, or locally at RTS. This distributed command and control of the system provides a way to automate certain functions, such as antenna pointing, target tracking, and data recording and processing. It also frees up

operator resources, particularly for more complex mission scenarios in which many telemetry links are present and antennas need to rapidly be redesignated as a scenario unfolds or flight vehicle trajectory geometries change.

Transforming Telemetry

The program will transform the way that telemetry information is collected and processed by providing software-defined, radio-based telemetry systems that will enhance not only the capabilities of RTS but also those of other test ranges conducting telemetry activities across the Department of Defense and industry. The modernized systems will

- Enable telemetry antennas and processing equipment to be centrally operated and automated from a control center
- Increase signal sensitivity by combining information from multiple antennas
- Reduce the staffing necessary to configure, operate, and maintain the ground-based telemetry sites
- Increase real-time availability of processed telemetry data

Future Directions

The U.S. Army RTS and Lincoln Laboratory will lead the way in the development and widespread deployment of software radio-based telemetry stations, receivers, and processing capability. The same novel software-based approach can be employed to utilize software radio technology in other sensor systems, such as multistatic radar systems, making them more adaptable to evolving mission needs and cost-effective to sustain and enhance over their life cycles. ■

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